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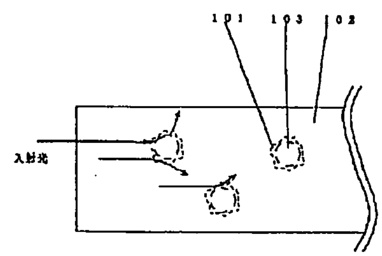
(54) GUIDE PLATE AND FLAT LIGHT EMITTING DEVICE USING IT

(57) Abstract:

PROBLEM TO BE SOLVED: To provide a flat light emission light source using a guide plate for use in a liquid crystal backlight, panel meter, indication lamp, flat light emitting switch, etc., capable of leading the light with a high brightness and with less deviation in the brightness in particular without risk that the light fed from the light source is absorbed inside the guide plate.

SOLUTION: A flat light emission device is equipped with a rectangular guide plate structured so that a diffusive material 103 is included in a transmissive guide 102, the material 103 having a refractive index different from the guide 102, and a light emitting diode connected optically with the end face of the guide plate for emitting light from its main surface. In particular, the guide 102 and diffusive material 103 are both made of transmissive resin, and the interface 101 between them is inclined in terms of composition from the resin constituting the diffusive material to the resin forming the guide.



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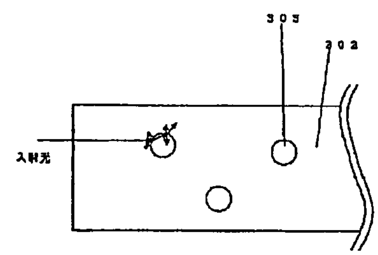

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TI: Light guide plate for sheet-like light emission device used for liquid crystal back light, has diffusion material and light guide made of transparent resin of different refractive indices

AB: NOVELTY - A diffusion material (103) is embedded in the light guide (102). Both the light guide and the diffusion material are made of transparent resin of different refractive indices. The optical path at boundary surface (101) of the diffusion material and the light guide is inclined. DETAILED DESCRIPTION - An INDEPENDENT CLAIM is also included for sheet-like light emission device.; USE - For sheet-like light emission device used for liquid crystal back light, panel meter, signal light and surface emission switch. ADVANTAGE - Since the optical path at boundary surface of diffusion material and light guide is inclined, absorption of light within light guide is prevented, thus the light guide plate with outstanding light emission characteristic is obtained. DESCRIPTION OF DRAWING(S) - The figure shows model sectional view of the light guide plate illustrating deviation of optical path. Boundary surface 101 Light guide 102 Diffusion material 103

PA: (NICH-) NICHIA KAGAKU KOGYO KK;
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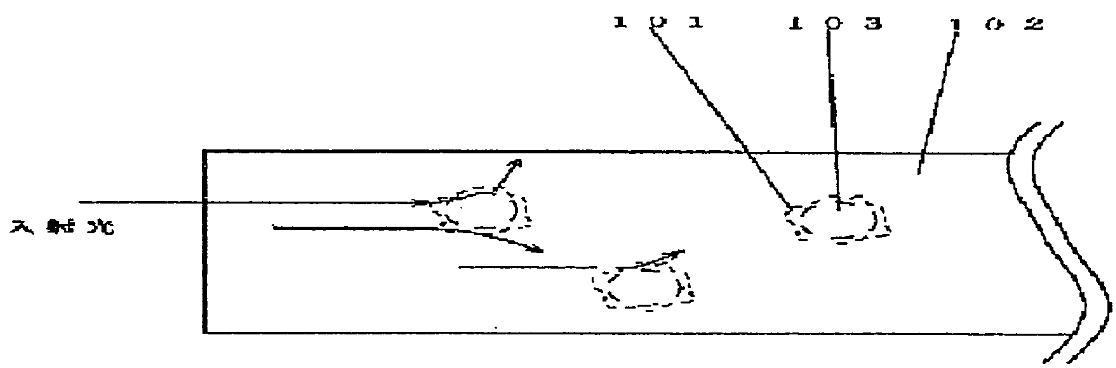

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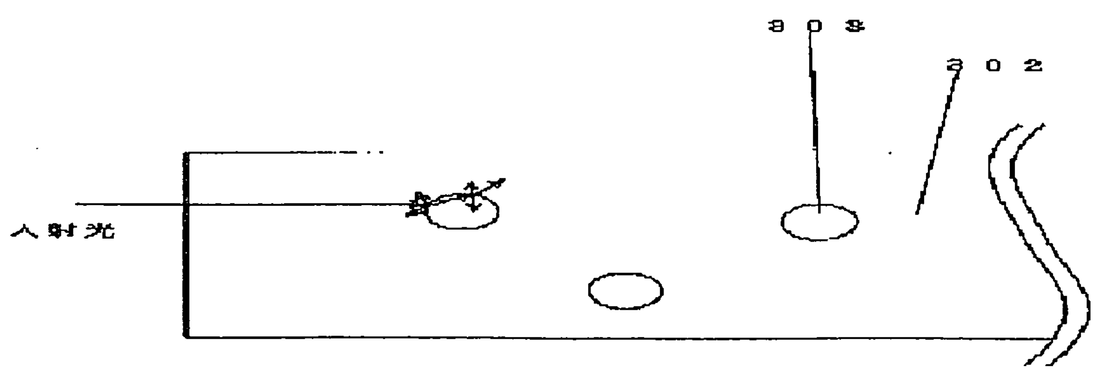

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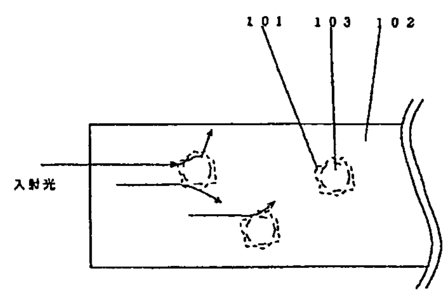
5F041 AA07 CA34 EE23 EE25 FF01 FF11

(54)【発明の名称】　導光板及びそれを用いた面状発光装置

(57)【要約】
【課題】液晶バックライト、パネルメーター、表示灯や面発光スイッチなどに用いられる導光板やそれを用いた面状発光光源に係わり、特に、光源から入射される光が導光板内部で吸収されることなく、より高輝度且つ輝度偏差が少なく導光可能な発光光源を提供することにある。
【解決手段】本発明の発光装置は、透光性の導光体（１０２）中に該導光体と異なる屈折率を有する拡散材（１０３）を含有させた矩形状の導光板と、該導光板の主面から光を放出させるために導光板の端面に光学的に接続させた発光ダイオードとを有する面状発光装置である。特に、導光体（１０２）及び拡散材（１０３）は共に透光性樹脂であり、且つ拡散材と導光体との界面（１０１）は拡散材を構成する樹脂から導光体を構成する樹脂に組成傾斜している面状発光光源である。



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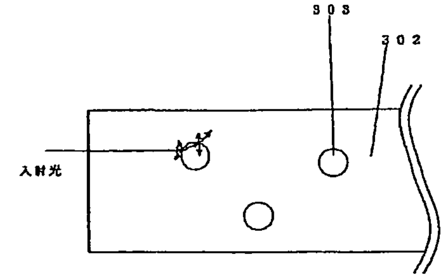

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【特許請求の範囲】

【請求項1】 透光性の導光体(102)中に該導光体と異なる屈折率を有する拡散材(103)を含有させた導光板であって、

前記導光体(102)及び拡散材(103)は熱変形温度の異なる透光性樹脂であり、且つ前記拡散材と導光体との界面(101)は拡散材を構成する樹脂から導光体を構成する樹脂に連続的に組成変化していることを特徴とする導光板。

【請求項2】 透光性の導光体(102)中に該導光体と異なる屈折率を有する拡散材(103)を含有させた導光板と、該導光板の端面から光を入射させ導光板の主面から光を放出させる発光体(106)とを有する面状発光装置(100)であって、

前記導光体(102)及び拡散材(103)は共に透光性樹脂であり、且つ前記拡散材と導光体との界面(101)は拡散材を構成する樹脂から導光体を構成する樹脂に組成傾斜していることを特徴とする面状発光光源。

【請求項3】 透光性の導光体(102)中に該導光体と異なる屈折率を有する拡散材(103)を含有させた矩形状の導光板と、該導光板の主面から光を放出させるために導光板の端面に光学的に接続させた発光ダイオードとを有する面状発光装置であって、

前記導光体(102)及び拡散材(103)は共に透光性樹脂であり、且つ前記拡散材と導光体との界面(101)は拡散材を構成する樹脂から導光体を構成する樹脂に組成傾斜していることを特徴とする面状発光光源。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、液晶バックライト、パネルメーター、表示灯や面発光スイッチなどに用いられる導光板やそれを用いた面状発光光源に係わり、特に、光源から入射される光を導光板内部で吸収されることなく、より高輝度且つ輝度偏差が少なく発光可能な面状発光光源などに関する。

【0002】

【従来技術】液晶バックライトなどに点光源として認識される発光ダイオード(以下、LEDともいう)からの光を面状に発光させる面状発光光源400が設けられている。このような面状発光光源の一例として図4に模式的斜視図を図5にその断面図を示す。図4は内部を光が透過可能であり発光面を構成する平面状の導光板410と、導光板410の一側部に設けられ、導光板側部から光を入射させる冷陰極管やLEDなどの発光体406が設けられている。また、導光板410の面状発光が観測される板状透光性樹脂の主面及びLEDが接続される端面を除いて反射板404が設けられている。こうして形成された面状発光光源400の発光体を光らせることにより、面状発光させることができる。

【0003】さらに、酸化珪素などの透光性無機材料などを用いた拡散材403を導光体402中に含有させることにより、面状発光光源400を構成する導光板410から放出される光を導光板内で拡散材で散乱・反射させる。これにより、導光板410を覆う反射板404に加えて導光板410内部の光透過経路を変更させることにより、面状発光光源400全体から高輝度に均一発光させられることが考えられる。

【0004】

【発明が解決しようとする課題】しかしながら、拡散材403を含有させた導光板410は、比較的簡単な構成でより高輝度化などを行うことが可能と考えられているにもかかわらず、発光体406からの光に対して十分な発光輝度をえることができなかった。そのため、発光体を構成するLEDなどの数を増やしたり、投入電力を多くすることによって対応していた。LEDなどの数を増やしたり投入電力を多くすることはコストが増大するだけでなく、二次電池などを利用した携帯用途の需要が多いバックライトなどではスペースをとることや消費電力が増大するなど種々の問題が生ずる。したがって、本発明は上記問題のない光利用効率の優れた導光板及びそれを用いた面状発光光源を提供することにある。

【0005】

【課題を解決するための手段】本発明者は、種々の実験の結果、導光板と導光板中に含有させる拡散材とを特定の関係とさせることにより、比較的簡単な構成で光利用効率が高い面状発光光源とすることができることを見いだし、本発明をなすに至った。即ち、本発明は透光性の導光体(102)中に導光体と異なる屈折率を有する拡散材(103)を含有させた導光板である。特に、導光体(102)及び拡散材(103)は熱変形温度の異なる透光性樹脂であり、且つ拡散材と導光体との界面(101)は拡散材を構成する樹脂から導光体を構成する樹脂に連続的に組成変化している導光板である。このような構成とすることにより導光板の外部から入射された光の吸収を抑制しつつ、拡散材及びその界面が光の進路を変更させて所望の導光板の形状に発光させることができる。

【0006】図3に本発明の作用を模式的断面図において説明すると、図3(B)の如く、導光体302中に拡散材303を単に含有させると、導光板に入射した矢印の如き光は拡散材303の界面において反射・散乱される。これにより、導光板から拡散光等を利用して有効に光を取り出すことができると考えられていた。しかし、拡散材の界面での拡散・反射時には、大幅な光の吸収を生ずる。また、入射経路から観測すると反射・散乱により、入射光は大幅に延びる。その結果、導光体などに吸収される割合も増え、導光板全体及び面状発光光源の光利用効率が低くなる。本発明は、図3(A)の如く、拡散材103と導光体102との界面101の組成が変化していることから、導光体と拡散材界面の拡散・反射時

における光吸収を極力さけ、且つ図の矢印の如く光を偏向させることにより光利用効率を高くすることができると考えられる。

【0007】本発明の請求項2に記載の面状発光装置は、透光性の導光体（102）中に導光体と異なる屈折率を有する拡散材（103）を含有させた導光板と、導光板の端面から光を入射させ導光板の主面から光を放出させる発光体（105）とを有する面状発光装置（100）である。特に、導光体（102）及び拡散材（103）は共に透光性樹脂であり、且つ拡散材と導光体との界面（101）は拡散材を構成する樹脂から導光体を構成する樹脂に組成傾斜している面状発光光源である。これにより、比較的簡単な構成で、導光板に入射された光を効率よく導光板から光を取り出せる面状発光装置とすることができる。そのため、光利用効率の高い、面状発光装置とすることができる。

【0008】本発明の請求項3に記載の面状発光装置は、透光性の導光体（102）中に該導光体と異なる屈折率を有する拡散材（103）を含有させた矩形状の導光板と、該導光板の主面から光を放出させるために導光板の端面に光学的に接続させた発光ダイオードとを有する面状発光装置である。特に、導光体（102）及び拡散材（103）は共に透光性樹脂であり、且つ拡散材と導光体との界面（101）は拡散材を構成する樹脂から導光体を構成する樹脂に組成傾斜している面状発光光源である。この構成により、上記効果に加えて、マクロ的には点光源として認識されるＬＥＤを用いてもＬＥＤ近傍が明るくその周辺が暗く観測されることなく輝度偏差が少ない均一面状発光が可能な面状発光装置とすることができる。

【0009】

【発明の実施の形態】図１（Ａ）は本発明の導光板を用いた面状発光装置の模式的斜視図であり、（Ｂ）は（Ａ）のＸＸ断面図である。本発明において導光板を導光体としてアクリル樹脂（熱変形温度７１～９９℃、屈折率１．４９）を用いる一方、拡散材として、ポリカーボネート樹脂（熱変形温度１４１℃、屈折率１．５９）を予め混合させたホッパを用いて射出成形により形成させた。

【0010】拡散材が導光体との界面で組成が傾斜勾配構成をもつためには、導光板を構成する導光体材料と拡散材材料の選択、導光板の形成時における、射出温度、金型内における冷却温度、時間及び圧力が重要となる。即ち、本発明の導光体に用いられる材料としては光透光性、形成性に優れ拡散材との界面が傾斜溶融行いものを好適に利用することができる。具体的導光体の材料としては、アクリル樹脂、ポリカーボネート樹脂、非晶性ポリオレフィン樹脂、ポリスチレン樹脂などが挙げられる。他方、拡散材としては、拡散材としての機能を満たすため導光体の材料の屈折率との差を比較的小さくすることで、より光利用効率を高められる傾向にある。また、組成傾斜させるためには、拡散材を構成する樹脂材料の熱変形温度が導光体を構成する樹脂材料の熱変形温度よりも高いことが好ましい。そのため、導光体材料との組み合わせにより拡散材の材料は、種々選択することができる。

【0011】具体的拡散材材料としてアクリル樹脂、ポリカーボネート樹脂、非晶性ポリオレフィン樹脂、ポリメチンペンテン樹脂やポリエチレンテレフタレート樹脂を好適に利用することができる。拡散材は効率よく導光板から光を取り出すために真球状を含めフィラー形状など種々の形状を選択することができる。また、拡散材の平均粒径も材料との選択などにもよるが、０．１μm以上３０μm以下であることが好ましい。同様に、粒子径中央値は３μmから２０μmが好ましい。導光板中における拡散材の含有量は、面状発光光源からの均一性を向上させるために０．００１％以上１％以下が好ましい。より好ましくは０．０１％以上０．２％以下である。このような拡散材は、上述の条件を満たす限り、１種類のみならず、２種類以上混合して用いることができる。

【0012】具体的導光板の形成条件としては、アクリル樹脂中に粒径の中央値が３μｍに調整したポリカーボネート樹脂を拡散材として０．１％添加した材料を射出成型させた。拡散材となるポリカーボネート樹脂の熱変形温度点以下であり、且つ導光体の熱変形温度以上である約２４０℃で溶融させながら７０Ｋｇ／ｃm^2の圧力で金型に押し込みさせた。なお、圧力は射出成型時に２段階以上変化させて１００から５０Ｋｇ／ｃm^2に調整させることもできる。本発明では金型を６０℃に加熱設定し、金型内に樹脂が全て注入後においても１０ｓから２分の時間をかけて樹脂温度が６０℃になるまで、保持する。一旦、樹脂温度が６０℃に一定となった後、金型から厚さ２㎜縦１０㎝横２ｃｍの板状導光板を取り出した。なお、導光板の底面形状は、発光均一にさせるために図１の如き、船底状板体１０９とさせたが、所望に応じて種々形成できることはいうまでもない。同様に、導光板の主面上にＬＥＤが配置される近傍から遠く離れるにつれ大きな凹凸を形成させ、面状に均一発光可能な導光板形状とすることもできる。

【0013】こうして、例えば導光体を構成する樹脂と拡散材を構成する樹脂の融点が近く、導光体が熱変形するだけの温度であっても、加圧成形すると共に冷却時間を一定時間長く取ることにより、導光体と拡散材との界面は拡散材を構成する樹脂から徐々に導光体を構成する樹脂に組成傾斜させることができる。なお、この形成条件を変化させることにより、組成傾斜を徐々に行うこともできるし、急激に行うこともできる。また、組成傾斜は連続的でも良いし断続的に形成することもできる。

【0014】形成された導光板に、透光性の接着材としてエポキシ樹脂を介してチタン酸バリウムが含有された

アクリル樹脂を反射材として貼り合わせた。反射材は、導光板を通じて面状に光を取り出す主面及び導光板の光を導入させる側の端面を除いて配置してある。また、反射材の設けられていない導光板の端面には、青色が発光可能な窒化物半導体からなるLEDチップ107及びLEDチップからの青色光によって励起され補色となる黄色光を放出する蛍光体を含有する樹脂108とを有する発光ダイオードを配置させてある。この発光ダイオードに電流を流すと白色光が導光板の端面から入射され、導光板の主面から面状に発光させることができる。形成された面状発光光源は、拡散材と導光体の界面が明瞭なものに比べて格段に輝度を向上させることができる。

【0015】また反射材104を、図2（B）に示すように、光を導入させる導光板の第1の端面と対向する第2の端面へ折り返し、続けて面状に光を取り出す主面側の一部に約2mmまで形成することにより、LEDチップ107から発光される光が第2の端面から外部へともれるのをなるべく防ぐことができる。図2のように導光板の形状が第2の端面に厚みがある場合には、厚みが少ない場合よりもLEDチップからの光が外部へともれる割合が大きくなるので、反射材を前記のように形成するとより効果的である。第2の端面に反射材が存在しない場合は、LEDチップからの光はそのまま発光装置の外部へともれてしまうが、存在すれば光は反射材により反射され面状に光を取り出す主面側へと拡散させることができ、LEDチップからの光をできるだけもれなく発光面から取り出すことができる。

【0016】また反射材104を導光板に接着させる際、透光性の高いアクリル系またはシリコン系の接着剤を用いるのがより好ましい。LEDチップからの光をより多く反射材まで到達させ、また反射した光もより多く発光主面側へと透過させるためである。さらに反射材として、LEDチップからの光を反射させるために酸化チタン、チタン酸バリウム、硫酸バリウム、酸化アルミニウム等の拡散反射材を添加した樹脂シートや、フィルムに銀、アルミニウム等の金属を蒸着した鏡面反射シート等を導光板に貼り合わせると、LEDチップからの光を効率よく取り出すことができる。

【0017】また、本発明による導光板を、固定枠等にはめ込んで利用する場合、その固定枠等自体を、PC、ABS、PBT等にLEDチップからの光を反射させるために酸化チタン、チタン酸バリウム、硫酸バリウム、酸化アルミニウム等の拡散反射材を添加して成形した樹脂で形成すると、反射材との効果とも加わって、LEDチップからの光の反射率を格段に向上させることができ、発光装置外部へと効率よく光を取り出すことができる。

【0018】以下、本発明の具体的の異なる導光板や面状発光光源を列記するがいずれも上述と同様に拡散材と導光体の界面に組成傾斜を持ち、量産性よく輝度偏差及び発光輝度の優れた面状発光光源とすることができる。本発明において上述の拡散材の代わりに、非晶性ポリオレフィン樹脂（熱変形温度162℃、屈折率1．51）のパウダーで粒子径の中央値を2μmに調整したものを拡散材として導光体の樹脂に重量で0．08％添加させてた以外同様にして形成させた。なお、導光板の形成・冷却条件は、約240℃で溶融させながら100〜50Kg／cm2の圧力で金型に押し込みさせた。金型を50℃に加熱設定し、金型内に樹脂が全て注入後においても1分の時間をかけて樹脂温度が50℃になるまで、保持する。一旦、樹脂温度が50℃に一定となった後に、金型から取り出し導光板を形成した。形成された導光板を用いた面状発光装置は上述面状発光装置の1．1倍の輝度があり、輝度偏差も1．02倍向上していた。なお、輝度偏差は、それぞれの導光板の対応する9点を取りそのばらつきを見たものである。

【0019】本発明において上述の拡散材の代わりに、ポリメチンペンテン樹脂（熱変形温度50℃、屈折率1．47）のパウダーで粒子径の中央値を5μmに調整したものを拡散材として導光体の樹脂に重量で1％添加させてた以外同様にして導光板を形成させた。なお、導光板の形成・冷却条件は、約240℃で溶融させながら100〜50Kg／cm2の圧力で金型に押し込みさせた。金型を80℃に加熱設定し、金型内に樹脂が全て注入後においても1分の時間をかけて樹脂温度が80℃になるまで、保持する。一旦、樹脂温度が80℃に一定となった後、金型温度を室温まで下げた後に、金型から取り出し導光板を形成した。上述と同様優れた発光輝度及び輝度偏差を有していた。

【0020】次に、ジエチレングリコールビスアリルカーボネート樹脂（屈折率1．50）を熱硬化させたブロックを粉砕分級した。形成された粒子径の中央値が1μmに調整したものを拡散材として導光体の樹脂に重量で0．1％添加させてた以外同様にして導光板を形成させた。なお、導光板の形成・冷却条件は、約240℃で溶融させながら100〜50Kg／cm2の圧力で金型に押し込みさせた。金型を160℃に加熱設定し、金型内に樹脂が全て注入後においても1分の時間をかけて樹脂温度が160℃になるまで、保持する。一旦、樹脂温度が160℃に一定となった後に、金型から取り出し導光板を形成した。上述と同様優れた発光輝度及び輝度偏差を有していた。

【0021】つづいて、導光体の樹脂をポリカーボネート樹脂（熱変形温度141℃、屈折率1．59）にする一方、拡散材の樹脂は非晶性ポリオレフィン樹脂（熱変形温度162℃、屈折率1．51）のパウダーで粒子径の中央値を2μmに調整したもの用いた。拡散材は導光体の樹脂に重量で0．08％添加させてある。なお、導光板の形成・冷却条件は、約270℃で溶融させながら150〜50Kg／cm2の圧力で金型に押し込みさせ

た。金型を１２０℃に加熱設定し、金型内に樹脂が全て注入後においても１分の時間をかけて樹脂温度が１２０℃になるまで、保持する。一旦、樹脂温度が１２０℃に一定となった後に、金型から取り出し導光板を形成した。このように形成された導光板は上述と同様に優れた発光輝度及び輝度偏差を有することができる。

【００２２】次に、導光体の樹脂をアクリル樹脂とする。ポリカーボネート樹脂のパウダーで粒子径の中央値を２μｍに調整したものを拡散材として導光体の樹脂に重量で０．０５％添加させた。導光板形成用の金型には発光面と対向する主面に凹凸を形成させてある。凹凸は、ＬＥＤの発光が均一となるようにＬＥＤの輝度が低下する箇所にその間隔が密となるよう徐々に多く形成させてある。なお、導光板の形成・冷却条件は、約２４０℃で溶融させながら１００〜５０Ｋｇ／ｃｍ2の圧力で金型に押し込みさせた。金型を６０℃に加熱設定し、金型内に樹脂が全て注入後においても１分の時間をかけて樹脂温度が６０℃になるまで、保持する。一旦、樹脂温度が６０℃に一定となった後に、金型から取り出し導光板を形成した。上述と同様優れた発光輝度とできるほかに、最も輝度偏差を高くすることができる。

【００２３】

【発明の効果】本発明は、拡散材の界面を組成傾斜した特定の関係とし、比較的簡単な構成で光の偏向を利用して発光輝度及び輝度偏差に優れた導光板及び面状発光光源とすることができるものである。

【図面の簡単な説明】

【図１】　（Ａ）は、本発明の一例である面状発光光源の模式的斜視図を示す。（Ｂ）は（Ａ）のＸＸ断面における模式的断面図を示す。

【図２】　（Ａ）は、本発明の一例である面状発光光源の模式的斜視図を示す。（Ｂ）は（Ａ）のＹＹ断面における模式的断面図を示す。

【図３】　本発明における発光輝度及び輝度偏差向上を説明するための模式的説明図を示す。

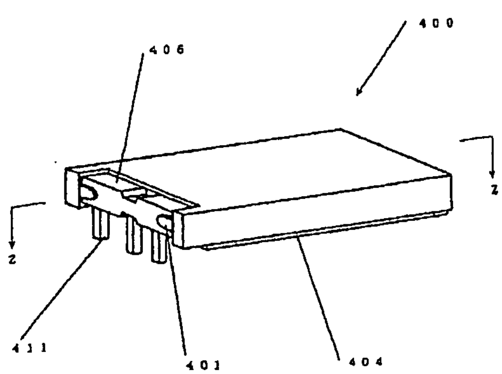
【図４】　本発明と比較のために示す面状発光光源の模式的斜視図を示す。

【図５】　図４のＺＺ断面における模式的断面図を示す。

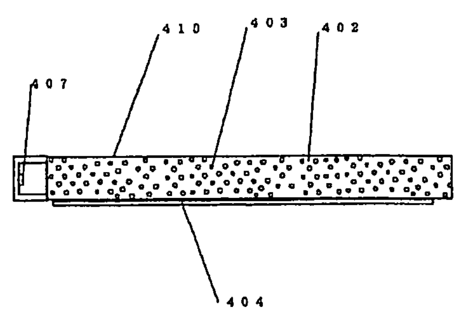
【符号の説明】

１００・・・面状発光光源
１０１・・・拡散材を構成する樹脂のみから導光体を構成する樹脂のみとの間にあって組成傾斜した部位
１０２・・・透光性樹脂からなる導光体
１０３・・・透光性樹脂からなる拡散材
１０４・・・導光板に設けられた反射板
１０５・・・ＬＥＤを利用した発光体
１０６・・・発光体を導光板に固定する手段
１０７・・・ＬＥＤチップ
１０８・・・ＬＥＤチップからの光によって可視光を発光する蛍光体が含有された樹脂
１０９・・・船底状の導光板底面
１１０・・・導光板
１１１・・・ＬＥＤチップに電流を供給するリード電極
３０２・・・導光体
３０３・・・拡散材
４００・・・面状発光光源
４０１・・・発光体を導光板に固定する手段
４０２・・・導光体
４０３・・・拡散材
４０４・・・反射板
４０６・・・発光体
４０７・・・ＬＥＤチップ
４１０・・・導光板
４１１・・・ＬＥＤチップに電流を供給するリード電極

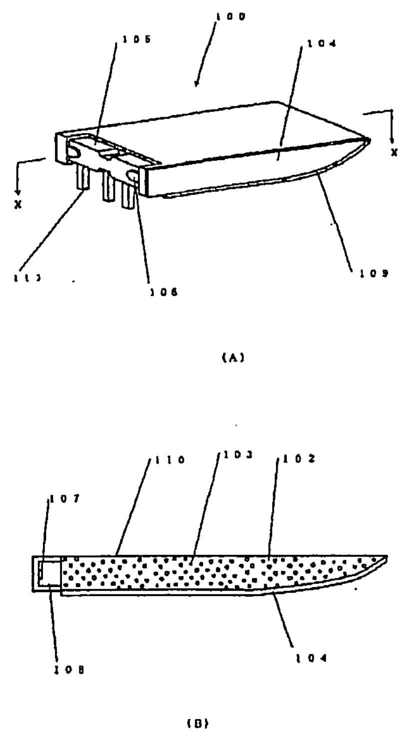
【図４】



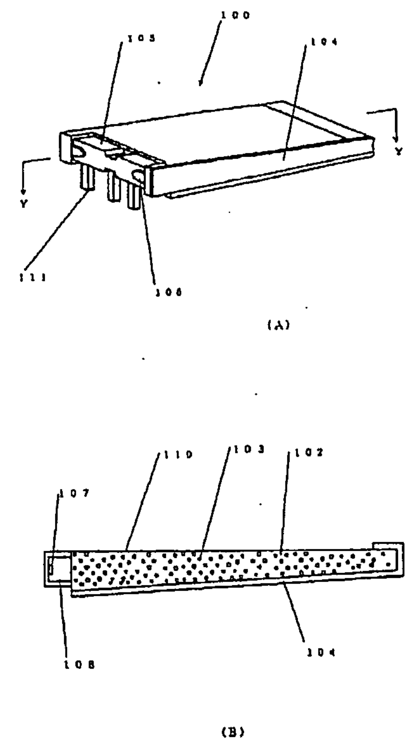
【図５】



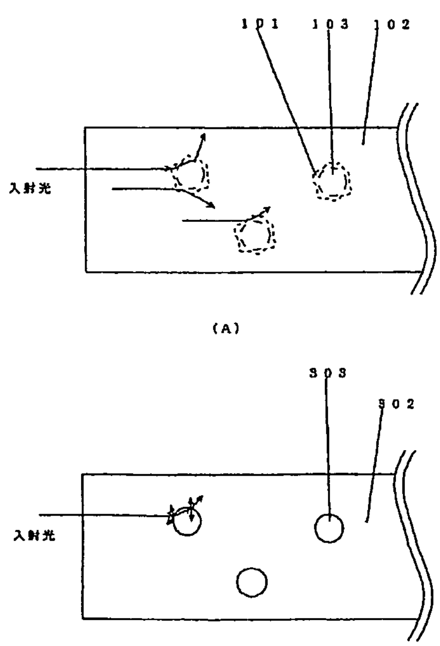
【図1】


100
105
104
X
X
111
106
109
(A)
110
103
102
107
108
104
(B)

【図2】


100
105
104
Y
Y
111
106
(A)
110
103
102
107
108
104
(B)

【図3】


101
103
102
入射光
(A)
303
302
入射光

(B)

(D10)

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(54) [Title of the Invention]

LIGHT GUIDE PLATE AND PLANAR LIGHT EMITTING DEVICE USING THE SAME

(57) [Abstract]

[Problem to be Solved]

The present invention relates to a light guide plate and a planar light source using the same used for an LCD backlight, a panel meter, an indicator lamp, a surface light emitting switch and the like. In particularly, the present invention provides a planar light source in which the light incident from a light source is not absorbed in the light guide plate and the light can be guided at high brightness and with less variation in brightness.

[Solution]

The light emitting device of the present invention is a planar light emitting device comprising a rectangular light guide plate including a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from that of the light guide, and a light-emitting diode optically connected to an end surface of the light guide plate to allow the light to go out of a principal surface of the light guide plate. In particular, in the planar light source, the light guide (102) and the diffusion material (103) are translucent resins, and the composition of the interface (101) between the diffusion material and the light guide changes from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner.

[Claims for the Patent]

[Claim 1]

A light guide plate comprising: a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from the index of refraction of the light guide,

characterized in that the light guide (102) and the diffusion material (103) are translucent resins having different thermal distortion temperatures, and the composition of the interface (101) between the diffusion material and the light guide continuously changes from the resin that forms the diffusion material to the resin that forms the light guide.

[Claim 2]

A planar light emitting device (100) comprising: a light guide plate including a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from the index of refraction of the light guide; and a luminous body (106) that introduces light through an end surface of the light guide plate, the light going out of a principal surface of the light guide plate,

characterized in that the light guide (102) and the diffusion material (103) are translucent resins, and the composition of the interface (101) between the diffusion material and the light guide changes from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner.

[Claim 3]

A planar light emitting device comprising: a rectangular light guide plate including a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from the index of refraction of the light guide; and a light-emitting diode optically connected to an end surface of the light guide plate to allow the light to go out of a principal surface of the light guide plate,

characterized in that the light guide (102) and the diffusion material (103) are translucent resins, and the composition of the interface (101) between the diffusion material and the light guide changes from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a light guide plate and a planar light source using the same used for an LCD backlight, a panel meter, an indicator lamp, a surface light emitting switch and the like. The present invention particularly relates to a planar light source and the like in which the light incident from a light source is not absorbed in the light guide plate and the light can be emitted at high brightness and with less variation in brightness.

[0002]

[Conventional Art]

An LCD backlight includes a planar light source 400 that converts the light from a light-emitting diode (hereinafter also referred to as LED), which is recognized as a point light source, into surface light emission. Figure 4 is a schematic perspective view showing an example of such a planar light source, and Figure 5 is a cross-sectional view of the planar light source. Figure 4 shows a planar light-transmissive light guide plate 410 that forms a light emitting plane, and a luminous body 406, such as a cold cathode tube and an LED, which is provided on one side of the light guide plate 410 and introduces light into the side of the light guide plate. Reflector plates 404 are also provided around the light guide plate 410 except the principal surface, which is made of plate-like translucent resin and where the surface light emission from the light guide plate 410 is observed, and the end surface to which the LED is connected. By

driving the luminous body in the thus formed planar light source 400 to emit light, surface light emission is provided.

[0003]

A light guide 402 contains a diffusion material 403 made of a light transmissive inorganic material, such as silicon dioxide, which scatters and diffuses the light to be emitted from the light guide plate 410 that forms the planar light source 400. It is thus conceivable that the light transmission path is changed not only in the light guide plate 410 but also by the reflector plates 404 that cover the light guide plate 410 to provide uniform light emission at high brightness from the entire planar light source 400.

[0004]

[Problems to be Solved by the Invention]

Although it is conceivable that the light guide plate 410 containing the diffusion material 403 is capable of providing high-brightness light emission with its relatively simple configuration, sufficient light emission brightness cannot be obtained from the light from the luminous body 406. To address this problem, the number of LEDs that form the luminous body is increased and/or the input power is increased. More LEDs and/or more input power causes various problems, not only higher cost but also more space and higher power consumption for a backlight or the like primarily used in portable applications that rely on a secondary battery. Accordingly, an object of the present invention is to provide a light guide plate that does not suffer from the above problems but provides excellent light usage

efficiency and a planar light source using such a light guide plate.

[0005]

[Means for Solving the Problems]

The present inventors have conducted various experiments, found that a specific relationship between the light guide plate and the diffusion material to be contained in the light guide plate allows a planar light source having a relatively simple configuration to provide high light usage efficiency, and thus attained the present invention. That is, the present invention provides a light guide plate comprising a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from that of the light guide. In particular, in the light guide plate, the light guide (102) and the diffusion material (103) are translucent resins having different thermal distortion temperatures, and the composition of the interface (101) between the diffusion material and the light guide continuously changes from the resin that forms the diffusion material to the resin that forms the light guide. In such a configuration, the light externally incident on the light guide plate will not be absorbed and the diffusion material and the interface therearound change the light path, allowing light emission of a desired shape of the light guide plate.

[0006]

The operation in the present invention will be described with reference to Figure 3, which is a schematic cross-sectional view. As shown in Figure 3(B), when a diffusion material 303 is simply contained in a light guide 302, the light incident on the

light guide plate indicated by the arrow is reflected and scattered at the interface around the diffuser plate 303. It has been considered that this configuration allows the light to be effectively taken out of the light guide plate as diffused light and the like. However, light is significantly absorbed in the diffusion and reflection process at the interface around the diffusion material. Furthermore, when observed in the incident path direction, the reflection and scattering significantly extend the incident light path, so that more light is absorbed in the light guide and the like, resulting in reduced light usage efficiency of the entire light guide plate and the planar light source. In the present invention, since the composition of the interface 101 between the diffusion material 103 and the light guide 102 changes, as shown in Figure 3(A), it is considered that the light usage efficiency can be enhanced by minimizing the light absorption in the diffusion and reflection process at the interface between the light guide and the diffusion material and deflecting the light as indicated by the arrows in the figure.

[0007]

The planar light emitting device according to claim 2 of the present invention is a planar light emitting device (100) comprising a light guide plate including a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from that of the light guide, and a luminous body (105) that introduces light through an end surface of the light guide plate, the light going out of a principal surface of the light guide plate. In particular, in

the planar light source, the light guide (102) and the diffusion material (103) are translucent resins, and the composition of the interface (101) between the diffusion material and the light guide changes from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner. There is thus provided a planar light emitting device in which the light incident on the light guide plate can be efficiently taken out of the light guide plate in a relatively simple configuration. There is thus provided a planar light emitting device having high light usage efficiency.

[0008]

The planar light emitting device according to claim 3 of the present invention is a planar light emitting device comprising a rectangular light guide plate including a light transmissive light guide (102) containing a diffusion material (103) having an index of refraction different from that of the light guide, and a light-emitting diode optically connected to an end surface of the light guide plate to allow the light to go out of a principal surface of the light guide plate. In particular, in the planar light source, the light guide (102) and the diffusion material (103) are translucent resins, and the composition of the interface (101) between the diffusion material and the light guide changes from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner. In the planar light emitting device having such a configuration, not only is the above advantageous effect provided, but also use of an LED, which is recognized as a point light source from a macroscopic point of view, does not lead to the situation in

which the vicinity of the LED is bright while the surroundings of the LED is dim, but provides uniform surface light emission with less variation in brightness.

[0009]

[Embodiments of the Invention]

Figure 1(A) is a schematic perspective view of a planar light emitting device using the light guide plate of the present invention, and Figure (B) is a cross-sectional view taken along the line XX in Figure 1(A). In the present invention, the light guide plate is formed by mixing an acrylic resin (thermal distortion temperature: 71 to 99°C, index of refraction: 1.49) as the light guide with a polycarbonate resin (thermal distortion temperature: 141°C, index of refraction: 1.59) as the diffusion material in a hopper in advance, followed by injection molding.

[0010]

Important factors to achieve a gradient composition at the interface between the diffusion material and the light guide are selection of the light guide material as well as the diffusion material that form the light guide plate, and injection temperature, cooling temperature in the die, time and pressure in light guide plate formation. That is, the material used for the light guide of the present invention may preferably have excellent light transmittance and formability, and cause gradient fusion at the interface to the diffusion material. Specific examples of the material of the light guide include acrylic resins, polycarbonate resins, amorphous polyolefin resins, and polystyrene resins. On the other hand, the diffusion material tends to further enhance light usage efficiency by

reducing the difference in index of refraction between the diffusion material and the light guide material to a relatively small value in order to achieve the function as the diffusion material. To achieve composition gradient, the thermal distortion temperature of the resin that forms the diffusion material is preferably higher than the thermal distortion temperature of the resin that forms the light guide. To this end, the diffusion material can be selected depending on the light guide material with which the diffusion material is combined.

[0011]

Preferred specific examples of the diffusion material include acrylic resins, polycarbonate resins, amorphous polyolefin resins, polymethylpentene resins, and polyethylene terephthalate resins. The diffusion material can be shaped into various forms including a sphere and a filler to efficiently take out light from the light guide plate. The average particle diameter of the diffusion material preferably ranges from 0.1 μm to 30 μm, although depending on the selection of the material. Similarly, the median particle diameter is preferably ranges from 3 μm to 20 μm. The content of the diffusion material in the light guide plate preferably ranges from 0.001% to 1% to improve the uniformity of the light from the planar light source, more preferably 0.01% to 0.2%. As the diffusion material, one material may be used or two or more materials may be mixed as long as the materials satisfy the above conditions.

[0012]

The light guide plate was specifically formed by adding a polycarbonate resin as the diffusion material, the median

particle diameter of which was adjusted to 3 μm, to an acrylic resin, the content of the polycarbonate resin in the acrylic resin being 0.1%, followed by injection molding. The mixture resin was melted at approximately 240°C, which is lower than or equal to the thermal distortion temperature of the polycarbonate resin, which was the diffusion material, but higher than or equal to the thermal distortion temperature of the light guide, and injected into the die under a pressure of 70 kg/cm^2. It is noted that the pressure can be changed by two or more steps and adjusted to 100 to 50 kg/cm^2 during the injection molding. In the present invention, the die was heated and set to 60°C, and all the resin injected into the die was held at 60°C for 10 seconds to 2 minutes until the temperature of the resin became 60°C. After the temperature of the resin reached 60°C and become stable, a plate-like light guide plate 2 mm thick, 10 cm long and 2 cm wide was removed from the die. Although the bottom of the light guide plate was shaped into a ship bottom-like plate 109 as shown in Figure 1 to make the light emission uniform, various other shapes can of course be used as desired. Similarly, irregularities can be formed in the principal surface of the light guide plate in such a way that the size of the irregularities becomes larger as being farther from where the LED is disposed so as to render the shape of the light guide plate capable of uniform surface light emission.

[0013]

In this way, for example, even when the melting point of the resin that forms the light guide is close to that of the resin that forms the diffusion material and the temperature in the die

only thermally distorts the light guide, the composition of the interface between the light guide and the diffusion material can be gradually changed from the resin that forms the diffusion material to the resin that forms the light guide in a gradient manner by pressure molding and long cooling for a fixed period. It is noted that the composition gradient may be gradual or abrupt depending on the forming conditions. Furthermore, the composition gradient may be continuous or discontinuous.

[0014]

An acrylic resin containing barium titanate is boned as the reflective material to the thus formed light guide plate via an epoxy resin as a light transmitting adhesive. The reflective material is applied to the light guide plate except the principal surface where the surface light emission is taken out of the light guide plate and the end surface where the light is introduced to the light guide plate. An LED chip 107 made of a nitride semiconductor capable of emitting blue light and a light-emitting diode including a resin 108 containing fluorescent material that is excited by the blue light from the LED chip to emit yellow light, which is complementary to blue, are disposed on the end surface of the light guide plate where no reflective material is applied. When current flows through the light-emitting diode, white light is introduced through the end surface of the light guide plate, and surface light emission is obtained through the principal surface of the light guide plate. The thus formed planar light source allows significant improvement in brightness, as compared to the brightness

achieved through a uniform interface between the diffusion material and the light guide.

[0015]

As shown in Figure 2(B), the reflective material 104 is folded onto the second end surface opposite to the first end surface of the light guide plate through which the light is introduced. The reflective material 104 is then formed on part (approximately 2 mm) of the principal surface through which surface light emission is taken out. In this way, it is possible to minimize the light emitted from the LED chip 107 and leaking through the second end surface to the outside. When the light guide plate is shaped in such a way that the second end surface has a certain thickness as shown in Figure 2, the amount of light from the LED chip that leaks to the outside is more than that leaking through a thinner end surface. It is therefore effective to form the reflective material as described above. Although the light from the LED chip directly leaks outside the light emitting device when there is no reflective material on the second end surface, provision of the reflective material allows the light to be reflected off the reflective material and diffused toward the principal surface through which surface light emission is taken out, thus maximizing the light from the LED chip that is taken out of the light emitting surface.

[0016]

It is more preferable to use an acrylic-based or silicon-based highly light transmissive adhesive to bond the reflective material 104 to the light guide plate, so as to maximize the light from the LED chip that reaches the reflective material and

the reflected light that transmits toward the light emitting principal plane. Furthermore, the light from the LED chip can be efficiently taken out by using, for example, a resin sheet to which a diffusing reflective material, such as titanium oxide, barium titanate, barium sulfate, and aluminum oxide, is added, or a specular reflection sheet obtained by depositing metal, such as silver and aluminum, to a film, as the reflective material to reflect the light from the LED chip, and then attaching the resin sheet or the specular reflection sheet to the light guide plate.

[0017]

When the light guide plate according to the present invention is fitted in a fixture frame or the like for use, the fixture frame itself is preferably molded using a mixture resin obtained by adding a diffusing reflective material, such as titanium oxide, barium titanate, barium sulfate, and aluminum oxide, to PC, ABS, PBT or the like to reflect the light from the LED chip. The thus formed fixture frame, in conjunction with the advantageous effect of the reflective material, can significantly improve the reflectance of the light from the LED chip, allowing the light to be efficiently taken out of the light emitting device.

[0018]

Various specific light guide plates and planar light sources according to the present invention will be listed below. Any of the planar light sources has composition gradient at the interface between the diffusion material and the light guide as in the above embodiment and provides good productivity, less

variation in brightness, and excellent light emission brightness. In the present invention, the light guide plate was formed in a manner similar to the above embodiment except that the diffusion material described above was replaced with a powdery amorphous polyolefin resin (thermal distortion temperature: 162°C, index of refraction: 1.51), the median particle diameter of which was adjusted to 2 μm, which was added as the diffusion material to the resin of the light guide, the content of the diffusion material in the light guide being 0.08% by weight. The light guide plate was formed and cooled in such a way that the mixture resin was melted at approximately 240°C and injected into the die under a pressure of 100 to 50 kg/cm^2. The die was heated and set to 50°C, and all the resin injected into the die was held at 50°C for 1 minute until the temperature of the resin became 50°C. After the temperature of the resin reached 50°C and became stable, the formed light guide plate was removed from the die. The planar light emitting device using the thus formed light guide plate provided brightness 1.1 times that of the planar light emitting device described above, and the variation in brightness also improved by 1.02 times. It is noted that the variation in brightness is defined by the variation among the brightness values at predetermined nine points on each light guide plate.

[0019]

In the present invention, the light guide plate was formed in a manner similar to the above embodiment except that the diffusion material described above was replaced with a powdery polymethylpentene resin (thermal distortion temperature: 50°C, index of refraction: 1.47), the median particle diameter of

which was adjusted to 5 μm, which was added as the diffusion material to the resin of the light guide, the content of the diffusion material in the light guide being 1% by weight. The light guide plate was formed and cooled in such a way that the mixture resin was melted at approximately 240°C and injected into the die under a pressure of 100 to 50 kg/cm^2. The die was heated and set to 80°C, and all the resin injected into the die was held at 80°C for 1 minute until the temperature of the resin became 80°C. After the temperature of the resin reached 80°C and became stable, the temperature of the die was cooled down to room temperature and then the formed light guide plate was removed from the die. The light guide plate had excellent light emission brightness and less variation in brightness as in the above embodiment.

[0020]

Next, a block of a thermally hardened diethylene glycol bis allyl carbonate resin (index of refraction: 1.50) was ground and classified. The light guide plate was formed in a manner similar to the above embodiment except that the thus formed resin, the median particle diameter of which was adjusted to 1 μm, was added as the diffusion material to the resin of the light guide, the content of the diffusion material in the light guide being 0.1% by weight. The light guide plate was formed and cooled in such a way that the mixture resin was melted at approximately 240°C and injected into the die under a pressure of 100 to 50 kg/cm^2. The die was heated and set to 160°C, and all the resin injected into the die was held at 160°C for 1 minute until the temperature of the resin became 160°C. After the temperature of

the resin reached 160°C and became stable, the formed light guide plate was removed from the die. The light guide plate had excellent light emission brightness and less variation in brightness as in the above embodiment.

[0021]

Next, a polycarbonate resin (thermal distortion temperature: 141°C, index of refraction: 1.59) was used as the resin of the light guide, and a powdery amorphous polyolefin resin (thermal distortion temperature: 162°C, index of refraction: 1.51), the median particle diameter of which was adjusted to 2 μm, was used as the resin of the diffusion material. The diffusion material was added to the resin of the light guide, the content of the diffusion material in the light guide being 0.08% by weight. The light guide plate was formed and cooled in such a way that the mixture resin was melted at approximately 270°C and injected into the die under a pressure of 150 to 50 kg/cm^2. The die was heated and set to 120°C, and all the resin injected into the die was held at 120°C for 1 minute until the temperature of the resin became 120°C. After the temperature of the resin reached 120°C and became stable, the formed light guide plate was removed from the die. The thus formed light guide plate can have excellent light emission brightness and less variation in brightness as in the above embodiment.

[0022]

Next, an acrylic resin was used as the resin of the light guide. A powdery polycarbonate resin, the median particle diameter of which was adjusted to 2 μm, was added as the diffusion material to the resin of the light guide, the content

of the diffusion material in the light guide being 0.05% by weight. The die for forming the light guide plate had irregularities in the principal surface facing the light emitting surface. More irregularities were formed at the location where the brightness of the LED decreased to make the light emission of the LED uniform in such a way that the interval of the irregularities became gradually narrower. The light guide plate was formed and cooled in such a way that the mixture resin was melted at approximately 240°C and injected into the die under a pressure of 100 to 50 kg/cm^2. The die was heated and set to 60°C, and all the resin injected into the die was held at 60°C for 1 minute until the temperature of the resin became 60°C. After the temperature of the resin reached 60°C and became stable, the formed light guide plate was removed from the die. The thus formed light guide plate can have not only excellent light emission brightness as in the above embodiment but also least variation in brightness.

[0023]

[Advantage of the Invention]

The present invention provides a light guide plate and a planar light source in which the interface around the diffusion material has a specific composition gradient and light deflection is used in a relatively simple configuration to provide excellent light emission brightness and less variation in brightness.

[Brief Description of the Drawings]

[Figure 1]

Figure 1(A) is a schematic perspective view of a planar light source, which is an example of the present invention. Figure 1(B) is a schematic cross-sectional view taken along the line XX in Figure 1(A).

[Figure 2]

Figure 2(A) is a schematic perspective view of a planar light source, which is another example of the present invention. Figure 2(B) is a schematic cross-sectional view taken along the line YY in Figure 2(A).

[Figure 3]

Figure 3 is a schematic explanatory view for explaining improvement in light emission brightness and variation in brightness in the present invention.

[Figure 4]

Figure 4 is a schematic perspective view of a planar light source shown for comparison with the present invention.

[Figure 5]

Figure 5 is a perspective cross-sectional view taken along the line ZZ in Figure 4.

[Description of Symbols]

100 ... planar light source

101 ... portion having composition gradient between resin that forms diffusion material and resin that forms light guide

102 ... light guide composed of translucent resin

103 ... diffusion material composed of translucent resin

104 ... reflector plate provided on a light guide plate

105 ... luminous body using LED

106 ... means for fixing a luminous body on the light guide plate

107 ... LED chip

108 ... resin containing fluorescent material that is excited by light from LED chip to emit visible light

109 ... ship bottom-like light guide plate bottom

110 ... light guide plate

111 ... lead electrode for supplying current to the LED chip

302 ... light guide

303 ... diffusion material

400 ... planar light source

401 ... means for fixing a luminous body on the light guide plate

402 ... light guide

403 ... diffusion material

404 ... reflector plate

406 ... luminous body

407 ... LED chip

410 ... light guide plate

411 ... lead electrode for supplying current to the LED chip

Figure 3(A)

Incident light

Figure 3(B)

Incident light